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March 4,2003

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: IB Docket No. 97-95

Dear Ms. Dortch

Please be advised that today the attached material was delivered to Ron Netro of the Wireless Telecommunications Bureau and Ron Repasi, Jason Frederick, Edward Jacobs, Trey Hanbury, Paul Lock and David Strickland of the International Bureau. This letter is a follow up to an October 24,2002 meeting held between those Commission staffers and Joseph M. Sandri, Jr., Vishnu Sahay, Gene Rappoport and the undersigned from Winstar Communications, LLC and Angie Kronenberg of Willkie, Farr & Gallagher, counsel to Winstar. In the meeting Winstar outlined its position in the above-referenced docket and its participation in the WRC-2003 preparation process. In addition, Winstar referenced on-going simulation modeling studies it was running. The attached information includes a paper submitted to the ITU entitled "Considerations on the Impact of Downlink Power Control upon FS Systems at 37.5-40 and 40.5-42 GHz" authored by Winstar. Attached please also find CITEL and ITU documents referenced in the Winstar's letter.

Please feel free to contact me with any questions regarding this filing. I may be reached at (202) 367-7610.

Very Truly Yours,

Lynne Hewitt Engledow

Lynne Hewitt Engledow
Winstar Communications, LLC

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Office of Secretary

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March 4. 2003

Mr. Ronald Repasi
Mr. Ronald Netro
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: in the Matter of Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequencv Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequencv Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequencv Band for Wireless Services: and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations: IB Docket No. 97-95

Dear Messrs. Kepasi and Netro,

On October 24,2002, representatives of Winstar Communications, LLC, an IDT Company, met with staff members of the International Bureau[1] regarding the Further Notice of Proposed Rulemaking (FNPRM) adopted on May 24, 2001, associated with IB Docket 97-95.

This letter provides both historical information discussed at that meeting and data subsequently developed through simulation modeling and other research techniques. At the meeting Winstar expressed its interest regarding the status of the FNPRM and its concern regarding protection of its service and its customers. Winstar discussed the fact that the required level of Fixed Service (FS) protection from space to Earth transmissions of the Fixed Satellite Service (FSS) had been compromised by negotiations at various international meetings and that any further permitted increase in transmit power due to fade conditions being experienced by the FSS would cause further unacceptable harmful interference to its customers. Winstar advised the Commission that it intended to perform additional simulation modeling to corroborate previous U.S. Government positions and conclusions regarding the required level of FS protection and to provide the results of those simulations to the Commission. Relatedly, Winstar created studies in response to ongoing U.S. preparations for the upcoming, April 11-17, 2003, Working Party 4-9S meeting in Geneva. Switzerland. (See attachment 1.)

Historical Context & Recent Simulations

All stakeholders in the U.S. preparatory process agreed to the level of protection required by FS applications in the band 37.5-40.0 GHz via a U.S. contribution to the CITEL PCC III meeting in March 2000. (See attachment 2.) Recently completed simulation modeling corroborates that the

[1] International Bureau attendees included Messrs. Frederick, Hanbury, Jacobs, Locke, Repasi and Strickland. Attendees from Winstar included Gene Rappoport, Vishnu Sahay, Joseph M. Sandri, Jr., Lynne N. Hewitt and Angie Kronenberg.

proposed power level in this contribution provided for an FSS transmit power that results in an increase in I/N of 10 dB for approximately 0.9% of FS stations.

Extensive discussion at the 2000 CITEL meeting and further compromise by Winstar resulted in an increase in permitted FSS transmit power from 1.5 to 13.5 dB that would be received at higher elevation angles of Winstar customer premise antennae. Note that the largest increase occurred in the 5-25 degree range, an elevation angle required for a high percentage of customer locations. Simulation modeling recently completed shows that this compromise resulted in an increase to up to 2% of FS stations that would be affected. This concluded in a CITEL Inter-American Proposal (IAP) to WRC-2000. This IAP was signed on to by the **USA** and nine other CITEL administrations.

At WRC-2000 Resolution 84 established pfd limits, on a provisional basis, in accordance with the values in Table S21-4 of the Radio Regulations. These limits provide for **8** dB of additional protection at elevation angles of 0-5 degrees but allow significantly more downlink transmit power for the FSS at elevation angles above 5 degrees. From 15-25 degrees the increase in permitted power from the U.S. proposal to CITEL ranges from 20-23 dB and from the IAP from 7.8-13 dB. At elevation angles above 25 degrees the increase in permitted power ranges from 15-20 dB from the original U S . proposal and is an increase of 13.5 dB from the CITEL IAP. Simulation modeling recently completed shows that the increases adversely impact up to 15% of high density FS stations.

Resolution 84 of WRC-2000 provides that administrations within Region 2 will not bring into service a frequency assignment for a GSO FSS network in the band 37.5-40.0 GHz without seeking the agreement of any administration in Region 2 on whose territory the pfd produced exceeds the limits in Table 21-4 minus 12 dB. Industry Canada and the FCC agreed to these same limits in a bi-lateral agreement.[2] At the CITEL PCC II meeting in Orlando, Florida, February 3-7,2003, Resolution 2 Power Flux Density (PFD) Limits in the Bands 37.5-40.0 GHz for the Fixed-Satellite Service, was adopted with these same limits and with the same provisions as in Resolution 84 (WRC 2000) for administrations within Region 2. Even at these reduced limits, simulation modeling recently completed shows adverse impact to 2.6% of high density FS stations by an increased I/N of 10 dB.

<u>Stop Continued Erosions</u>

Winstar remains greatly concerned that any further loss of protection due to increased FSS transmit power during fade conditions seriously compromises the service that it provides to its customers, which include numerous federal agencies and financial and commercial institutions. As documented in the information provided to the IB staff at the October 24, 2002 meeting, Winstar publicized, and in some cases contracted, to provide 99.999% availability. The constant threat of increased down link power from FSS transmitters during fade conditions in spot beam coverage areas create unnecessary and harmful exigencies.

[2] ***See*** *FCC and* ***Industry*** *Canada Sign Arrangement* ***on Principles Governing Use of*** *37.5-42.5 GHz Band,* FCC News, **May 28,2002.**

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The attached recent simulation modeling shows that FSS pfd levels, even at 12 dB below the levels in Table 21-4 of Article 21 of the Radio Regulations, cause harmful interference to approximately 2.6% of customer premise stations, dependent upon latitude and separation between the Earth station and Fixed Service station sites. Industry Canada and the **FCC** set this limit for satellite systems designed to operate in the V-band, to ensure protection of FS in the band 37.5-40.0 GHz. The limits in Table 21-4 result in harmful interference to, for example, **up** to 15% of customer premise stations at 40° latitude. (See attachment 1.)

The attached simulation modeling shows that various step increases in power, up to the Table 21-4 limits, negatively impact the Winstar network and its customer service. These results take into account the geographic area deployment of the high density FS, including multiple metropolitan areas falling within a single FSS satellite spot beam.

<u>Solutions</u>

Winstar agrees with the Coinmission that FSS gateway Earth stations require deployment in a manner that minimizes their effect, including during fade conditions, to the High Density Fixed Service, in the band 38.6-40.0 GHz. The most desirable deployment methods include using geographic diversity in gateway Earth station locations to minimize using automatic transmit power control to overcome fade conditions caused by rain attenuation. Another deployment option iiting the gateway stations in dry climate areas to again minimize fade condition occurrence and duration, thus removing or decreasing the need to increase power. **A** third option includes siting the gateway stations in unpopulated or sparsely populated areas, thus reducing spot beam overlap into a IIDFS service area.

The Commission may also wish to consider the use of coding related fade compensation methods. These methods are discussed in annex 2 of the ITU-R working document towards a draft new recommendation (4-9/S/DFC-40 GHz). (See attachment **3.)** In this approach an adjustable data rate strategy is adopted whereby either the coding, the modulation or both would be adjusted to provide the necessary performance in the event of varying rain rates, without increasing the power level.

Winstar requests that the Commission carefully consider the potential effect of **FSS** power increases, within the total spot beam area on the high density FS stations within the spot beam and outside the faded area. Additionally, Winstar asks the FCC to consider the possibilities for siting gateway stations in the band 38.6-40.0 GHz in a manner to minimize the effect on the Fixed Service.

Very Truly Yours,

Joseph M. Sandri, Jr.
Winstar Communications, **LLC**
SVP, Regulatory Counsel

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cc: Jason Frederick
Trey Hanbury
Edward Jacobs
Paul Locke
David Strickland

Attachments

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ATTACHMENTS INVENTORY

1. "Considerations On The Impact Of Downlink Power Control Upon FS Systems at 37.5-40 and 40.5-42 GHz", Reference: PDNR 4-9S/DFC-40 GHz; Document USWP 4-9S/1 Rev. 2; Authors: V. Sahay, J. Sandri, G. Rappoport; Feb. 25,2003.

2. Document 1604, "Proposals for Agenda Item 1.4; Proposal to modify ART S5, Table S21-4 of ART S21 and the suppression of Res 129 and 133", XV Meeting of CITEL Permanent Consultative Committee III, March 6-10, 2000, Mar del Plata, Argentina

3. "The extent to which GSO FSS satellites providing services to gateway earth stations in the bands 37.5-40 GHz and 40.5-42.5 GHz would need to operate at power flux-density levels in excess of a given clear-sky power flux-density levels to overcome fading conditions", **Annex** 2 to PDNR [4-9S/PRD-40GHz]; April, 2002.

ATTACHMENT 1

Radiocommunication Study Group
Fact Sheet

Group: WP 4-9S	Document USWP **4-9S**/1 Rev. 2
Reference: PDNR 4-9S/DFC-40 GHz	Date: February 25,2003
Document Title:	Considerations On The Impact Of Downlink Power Control Upon FS Systems at 37.5-40 and 40.5-42 **GHz**
Author: V. Sahay	Phone: 202 367-7607 Email: vsahavO.winstar.com
J. Sandri	Phone: 202 367-7643 Email: jsandri@winstar.com
G. Rappoport	Phone: 202 367-7603 Email: grappoport@winstar.com

1 Purpose/Objective

This contribution is intended to add information to PDNR 4-9S/DFC-40 **GHz,** or alternatively, to develop a draft new Recommendation, to provide guidance to FS and FSS system designers and Regulators on the impact upon FS p-p and p-mp systems from different levels of pfd from **GSO** systems operating in the band 37.5-40 **GHz** through the use of downlink power control.

Abstract:

In order to meet Table 21-4 limits, or any other limits imposed by Regulators, it is estimated that most FSS operators will employ fade compensation techniques including the use of downlink power control. In this case, they would work at clear air levels sufficiently below such limits in order to be able to compensate for rain fades. The use of downlink power control within a rain cell will impact FS receivers outside that rain cell. Through stochastic modeling of FS systems (using Monte Carlo techniques) it is possible to provide guidance on the percentage of FS systems which would be affected. This information would be useful for system designers and regulatory authorities.

INTERNATIONAL TELECOMMUNICATION UNION
RADIOCOMMUNICATION STUDY GROUPS

Document US WP 4-9S-1 R2
February 10,2003
English only

Reference: 4-9S/301: PDNR [SF.DFC-40 GHz]

United States **of** America

Considerations On The Impact Of Downlink Power Control Upon FS Systems at **37.5-40** and **40.5-42** GHz

1. Introduction

In the **37.5-40 GHz** and **42-42.5** GHz bands, ***invites*** *ZTU-R* **7** of Resolution **84,** invited the ITU-R to study the nominal clear-sky power flux-density levels **(see *resolves* 2** of Resolution **84),** and the percentage of time during which they may be exceeded to overcome fading conditions between the satellite and one or more geographically separated earth stations, in order to protect the fixed service while permitting operation of **FSS** earth stations using, for example, coordinated large antennas, taking into account the balance of constraints on both FSS systems and the fixed service.

Working Party **4-9S** has been studying the issue and Attachment **4** of the Chairman's Report of the April **2002 4-9S** meeting (Doc **4-9S/301)** contains a **"Framework"** towards a Preliminary Draft New Recommendation on the subject of the use of downlink fade compensation techniques by GSO FSS networks in the bands **37.5-40 GHz** and **40.5-42.5** GHz and their effect on FS systems. Considerings k) and l) of that PDNR describe a need to evaluate the impact of such techniques, assuming that FSS systems will require, for limited periods of time, satellite power increases above the clear sky levels. Considering l) recognizes that administrations will need guidelines on the impact such techniques would have on frequency band sharing between the FSS and the FS as applicable on their territories.

2. Correlation Between Fading on the Wanted and Interference Paths **from** a Satellite

Discussions within WP **4-9S** have not come to a conclusion on the amount of fading to expect on the interfering path and the duration of such fades, and has identified the need for further work in this area. Working Party **3M** has responded to inquiries on the relationship between fading on the satellite to earth station and the satellite to FS station paths for various separation distances. In document **4-9S/299** it has provided a methodology for assessing the probability of increase in interference to FS receivers due to the use of downlink power in satellite networks. However it acknowledges that models which would permit assessment of the probability of fade differentials of particular values are not yet developed. During such fades the increased interference level, could cause additional FS receivers to receive interference beyond acceptable I/N protection ratios. More importantly, it uses annual rainfall statistics in order to derive the probability of having less attenuation on the interference path than on the satellite wanted path. From the perspective **of** a system operator, interference during the worst month of the rainy seasons is far more important than the average over a whole year. Attachment 5 of the Chairman's report gives the results of studies showing the distribution, size, and speed of rain cells in some areas in North America, which occur during the rainy seasons. Differential fade statistics during such periods is very likely to be very different than average annual statistics. For this reason, [Winstar][The United States] has suggested in a companion paper that WP 3M be requested to continue to study the question of differential fades, taking into account the phenomena discussed in Attachment 5 of the Chairman's Report mentioned above.

In the absence of such information, assessment of the impact of increases in satellite power due to rain fades by any other method would not appropriately characterize the situation and thus result in premature and likely unreliable conclusions. Until such time as such key information becomes available from 3M, the operational systems study groups, such as 4 and 9, can only obtain an assessment of an upper bound on the probability of occurrence of increased interference. The key indicator for this is the increase in percentage of FS receivers that would be affected by different levels of satellite power increase due to rain fades.

3. Impact of Increasing Power Levels Due to Rain Fades

As satellite power levels increase in response to rain fades, the number of FS receivers affected by interference would also increase unless there is an equal amount of attenuation, or more, on the interference path. It is possible to assess the increase in interference due to various values of differential fades. Since, at present, the nature and duration of such differential fading events is not known, an upper bound is of limited use. It is also of interest to determine the variation of this differential fading with separation distance between the gateway earth station and the area of operation of the FS stations.

In this analysis, the technical parameters are as follows:

FSS: Satellites spaced every 4 degrees over the visible arc with boresight on **or** near **20°, 40°,** 50°N latitude and 100°W. The satellites meet the specified pfd requirements at boresight in clear air. Satellite beamwidth 0.3-0.6". In case of rain at the boresight, all satellites increase power simultaneously.

FS: Receiver noise figure 4dB and system noise temperature 740K.
Receiver antenna gain = 44.2dBi
Receiver elevation angle statistics:

FS Elevation Angle Distribution					
Elevation	0	10	25	45	60
%	0	52	71	91	100

Figures 1,2 and 3 show the resulting percentage of locations affected for the three latitudes assuming with 100 km separation separating the boresight and the FS operating region. Similar charts are available for the other distances assumed: 0, 50 and 200 km.

Tables 1, 2 and 3 present the percentage of cases at I/N>-10 dB.

Table 1: Percent FS locations where I/N >-10 dB (10% ratio) With PFD = Table 21-4 minus 12 dB and Latitude = 20N				
PFD Increase (dB)	Distance between ES and FS stations			
	0 km	50 km	100 km	200 km
0	1.6	1.7	1.7	1.4
+2	2.2	2.2	2.2	1.8
+4	3.0	2.9	2.8	2.4
+6	4.1	4.0	3.9	3.1
+8	5.7	5.5	5.4	4.3
+10	8.0	7.7	7.4	5.9
+12	10.9	10.6	10.1	8.1

Table 2: Percent FS locations where I/N >-10 dB (10% ratio) With PFD = Table 21-4 minus 12 dB and Latitude = 40N				
PFD Increase (dB)	Distance between ES and FS stations			
	0 km	50 km	100 km	200 km
0	2.6	2.6	2.5	2.2
+2	3.7	3.6	3.4	3.1
+4	4.7	4.6	4.4	4.2
+6	6.5	6.3	6.0	5.5
+8	8.6	8.4	7.9	7.4
+10	11.6	11.4	10.6	9.8
+12	15.2	14.9	13.9	12.6

Table 3: Percent FS locations where I/N >-10 dB (10% ratio) With PFD = Table 21-4 minus 12 dB and Latitude = 50N				
PFD Increase (dB)	Distance between ES and FS stations			
	0 km	50 km	100 km	200 km
0	2.5	2.5	2.4	2.1
+2	3.2	3.2	3.3	2.7
+4	4.7	4.5	4.5	3.7
+6	6.8	6.6	6.4	5.2
+8	10.0	9.4	9.1	7.4
+10	14.9	13.8	13.7	10.7
+12	19.3	18.1	17.7	13.7

4. Multiple Earth Stations

The above results are based upon the assumption that all the gateway earth stations are co-located. Additionally, it **is** assumed that there is only a single gateway earth **station** per satellite beam. The impact of these assumptions is to affect the percentage of time the FS systems are likely to be affected.

The assumption of co-located introduces a worst case element since it assumes that all satellite powers increase simultaneously and by the same amount. If the earth stations were separated, then the interference into a given FS receiver would have been determined by the nearest satellite in line with the direction of its antenna axis. Alternatively stated, the percentage of FS links would be lower than under the previous assumptions. However the percentage of time of a given FS receiver not meeting an I/N of **–10 dB** or of the short term criteria[1] would increase, assuming each earth station induces power increases in its own satellite due to rain fades independently of the others.

The assumption of multiple gateway earth stations per satellite causes the percentage of affected stations to rise since in this case the FS would at all times be subject to the power control level of the worst rainy satellite-gateway path. More importantly, it would also lead to an increase in duration of interference. In fact, in the worst case, with 'N' earth stations and a percentage of time that an I/N of –10 dB is not met is p for a given FS station, the net result would be $\mathbf{100\,(1 - (1 - p/100)^N)}$ assuming statistically independent fading.

Each of the above scenarios involving percentage of time a given I/N objective is not met requires differential fade data. Until then, the impact upon the FS in a single FSS gateway scenario is determined by the results in Tables **2-4** above.

5. Conclusion

Tables **1-3** provide the variation in percentage of cases which would be affected if satellites operate under the pfd limitations of RR Table **21-4** minus **12** dB, but can increase pfd in **2** dB increments up to the Table **21-4** maximum levels. As expected, variations with latitude are particularly significant since they are strongly influenced by the elevation angle statistics assumed for the FS systems. Also, due to satellite main beam roll off, the variation with distance from the ES boresight is not **as** significant until the difference approaches edge of beam coverage. Thus, to minimize the impact of satellites on an urbanized service, it would be desirable for gateway earth stations to be located such that the satellite beam avoids such urbanized areas. Further studies regarding multiple FSS gateway earth stations in a geographic operational area remain needed.

[1] **As determined** by **WP 9A (see doc. 4-9S/278)**

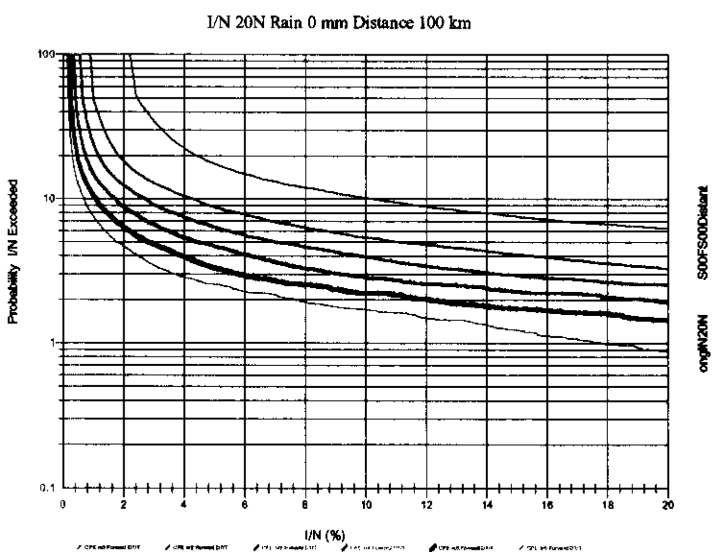
The significance of the levels in the Tables lies in the different pfd levels assumed for the FSS. The time statistics of the differential values shown **are** very important. As stated earlier, the differential fade statistics needed pertain to those during worst period, rather than yearlong averages. Working Party **3M** provided some useful data for the probability of increase of interference on an annual basis. But what is needed is statistics for the particular periods of rainfall activity described in Attachment **5**, such **as** worst month, and also the statistics on the amount of differential fade to expect.

In a separate document, [Winstar][the United States] recommends that Working Party **3M** study the differential rain statistics particularly under the situations described in Attachment **5** of the Chairman's Report. Until such time as the required information becomes available, WP **4-9S** cannot reliably predict the effect on **FS** receivers of **the** use of downlink power control as a means for overcoming rain fades. Alternative means for compensation **are** discussed in PDNR **[4-9S/DFC-40GHz]** Annex **2,** which discusses means available to avoid the **use** of downlink power control, such as adaptive coding and adaptive modulation. In addition the use of earth station diversity would assist in limiting the need to increase satellite power and thus the amount of interference.

6. Proposal

It is proposed that the results given in Tables **1-3,** the discussion on the need for differential fade statistics during high rain seasons, and on the need to consider the percentage of time impact of multiple earth stations be included in a new Annex to the PDNR and that this be drawn to the attention of WP **3M** and **3J.**

Figure **1: % FS** stations **I/N>-10** dB **20°N 100** km Separation



Key: From Top to Bottom: PFD = Table **21-4-0,4,6,8,10** and **12 dB**

Figure 2: % FS stations I/N>-10 dB 40°N 100 km Separation

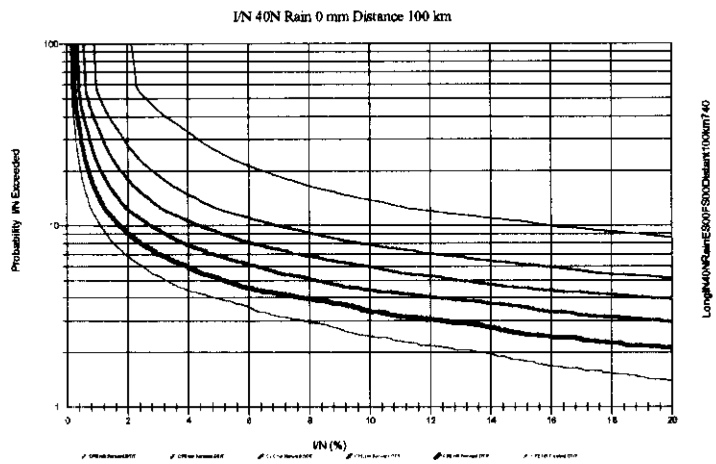
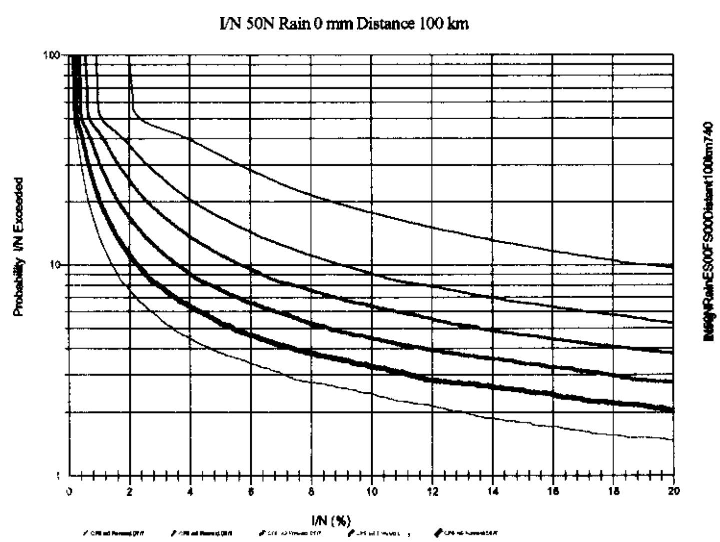


Figure 3: % FS stations I/N>-10 dB 20°N 100 km Separation



Key: From Top to Bottom: PFD = Table 21-4-0,4,6,8,10 and 12 dB

ATTACHMENT 2

XV MEETING OF PERMANENT CONSULTATIVE COMMITTEE III: RADIOCOMMUNICATIONS
March 6 to 10,2000
Mar del Plata, Argentina

OEA/Ser.L/XVII.4.3
PCC.III/doc 1604/00
6 March 2000
Original: English

Proposals for Agenda Item 1.4

Proposal to modify ART S5, Table S21-4 of ART S21 and the suppression of Res 129 and 133

(Item on the Agenda: 4.1)

(Document submitted by the Delegation of the United States of America)

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Proposals for Agenda Item 1.4

to consider issues concerning allocations and regulatory aspects related to Resolutions **126** (WRC-97), **128** (WRC-97), **129** (WRC-97), **133** (WRC-97), **134** (WRC-97) and **726** (WRC-97)

Proposal to modify ART S5, Table S21-4 of ART S21 and the suppression of Res 129 and 133

Background Information: ***Requests ITU-R*** 1 of Resolution **133** (WRC-97) requested the ITU-R to determine whether the power-flux density limits included in Article **S21 of** the Radio Regulations adequately protect terrestrial services from FSS networks in the band 37.0-40.0 GHz. Resolution **129** (WRC-97) requested the ITU-R to undertake studies of appropriate criteria and methodologies for sharing, including power flux-density limits, between the fixed-satellite service and the other services with allocations in the band 40.5-42.5 GHz.

According to the Report of the Conference Preparatory Meeting for WRC-2000 (CPM-99-2), the results of studies conducted in the ITU-R of known and proposed non-GSO **FSS** systems, and of known and proposed point to point (P-P) and point-to-multi-point (P-MP) FS systems, indicate that maximum allowable values of power flux-density of -120/-105 dB(W/(m^2-MHz)) at the surface of the earth would be adequate to protect systems operating in the fixed service from non-GSO **FSS** networks in the frequency hand 37.5 - 40.5 GHz. These results are applicable for protection of the Mobile Service in this band as well.

CPM-99-2 also reported that the results of studies conducted in the ITU-R of known and proposed non-GSO FSS systems, and of known and proposed P-P and P-MP **FS** systems, indicate that maximum allowable values of power flux-density of -115/-105 dB(W/(m^2-MHz)) at the surface of the **Earth** would he adequate to protect systems operating in the fixed service from non-GSO **FSS** networks in the frequency band 40.5 - 42.5 GHz. These results are applicable for the terrestrial Broadcasting Service in this band as well.

In both cases, the studies were deemed valid for non-GSO **FSS** systems comprised of 99 or fewer satellites, and independent verification would have to be performed if these levels were to be applied to any non-GSO **FSS** system with more than **99** satellites in its constellation. The results of the studies are reflected in Draft New Recommendation **[4-9S/AH1]**, Maximum Allowable Values of Power Flux-Density at the Surface of the Earth Produced by Non-Geostationary Satellites in the Fixed-Satellite Service Operating in the 37.5-40.5 GHz and 40.5-42.5 GHz Bands to Protect the Fixed Service.

With respect to power flux-density levels for GSO **FSS** systems in the 37.5-40 GHz and 40.5-42.5 GHz hands, CPM-99-2 identified two sets of methods to satisfy the Resolutions **133** and **129** agenda items. In one method, specific power flux-density levels of –125/ -105 dB(W/(m^2-MHz)) for the 37.5-40 GHz band GSO FSS systems and of –120/-110/ -105 dB(W/(m^2-MHz)) for the 40.5-42.5 GHz **band** GSO **FSS** systems, respectively – were identified as being adequate to protect co-frequency terrestrial systems. In the second method, it was suggested that it would be appropriate to develop varying power flux-density levels for application across the 37.5-42.5 GHz hand, hut the levels and band breaks were not specified. Neither method attained a consensus.

The United States recognizes that there is strong desire worldwide from both the satellite and terrestrial communities for access to spectrum in the 37.5-42.5 GHz band. Sharing between the two services has been shown to be technically feasible, but the conditions under which such sharing would equitably occur are not fully identified. The fixed service continues to evolve, and the fixed-satellite service has a requirement to establish at WRC-2000 the regulatory/procedural certainty that will enable networks that have been on file with the ITU's Radiocommunication Bureau since 1997 and earlier to proceed with implementation plans. Rather than continue to study sharing conditions within the ITU-R for another cycle, which will have the effect of freezing fixed service evolution and hampering the ability of fixed-satellite service networks to be established and globally deployed, the United States has developed the following proposals for modifications and additions to Article **S5,** Table **S21-4** of Article **S21**, Resolution **128** (WRC-97), and **for** the suppression of Resolutions **133** and **129** (both WRC-97). These proposals are intended to be considered as a comprehensive package that would establish on a worldwide basis the regulatory conditions that would permit the establishment and evolution of both the fixed service and the fixed-satellite service in the 37.5-**42.5** GHz frequency range.

Proposal

Article S5

GHz

37.5-40.5 GHz

USA/1.4/1
MOD

Allocation to services		
Region 1	**Region 2**	**Region 3**
37.5-38	FIXED FIXED-SATELLITE (space-to-Earth) **S5.HDFS** MOBILE SPACE RESEARCH (space-to-Earth) Earth exploration-satellite (space-to-Earth)	
38-39.5	FIXED FIXED-SATELLITE (space-to-Earth) **S5.HDFS** MOBILE Earth exploration-satellite (space-to-Earth)	
39.5-40	FIXED FIXED-SATELLITE (space-to-Earth) **S5.HDFS** MOBILE ~~MOBILE-SATELLITE (space-to-Earth)~~ Earth exploration-satellite (space-to-Earth)	
40-40.5	EARTH EXPLORATION-SATELLITE (Earth-to-space) FIXED **S5.FSS S5.MSS** FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth)	

USA/1.4/2
ADD

S5.HDFS In the bands 37.5-40.0 GHz and 42.0-42.5 GHz, stations in the fixed-satellite service shall not claim urotection from harmful interference from stations in the fixed service operating in this band. No. **S5.43** shall not apply.

Reason: To encourage fixed service and discourage fixed-satellite service use of these bands.

USA/1.4/3
ADD

S5.FSS In the band 40.0-42.0 GHz, stations in the fixed service shall not cause harmful interference to stations in the fixed-satellite service. nor claim protection from harmful interference from fixed-satellite service stations ouerating in this band. For sharing between the fixed-satellite service and other terrestrial services with co-primary allocations in this band. see Resolution **XXX**.

Reason: To encourage fixed-satellite service use and discourage fixed service use of this band.

USA/1.4/4

ADD

<u>**S5.N** n the band 40.0-4 stations in the fixed service not is fi f r **to** stations in the mobile-satellite service, **nor claim** tection from harmful interference from mobile-satellite service stati ting in th **band**.</u>

Reason: To encourage mobile-satellite service use and discourage fixed service use of this band

USA/1.4/5

MOD

'able S21-4 *(END)*

Frequency band	Service	Limit in dB(W/m^2) for angle of arrival (θ) above the horizontal plane					Reference bandwidth
			5° - 25°		25° - 90°		
31.0-31.3 GHz **34.7-35.2** GHz (space-to-Earth transmissions referred to in No. **S5.550** on the territories of countries listed in No. **S5.549**) ~~37.0-40.5 GHz~~	~~Fixed-satellite~~ ~~Mobile-satellite~~ Space research		-115 + 0.5 (θ-5) ~~[10]~~		-105 ~~[10]~~		1 MHz
37.0-37.5 GHz	Space research (Non-geostationary)	-115	-115 + 0.5 (θ-5)		-105		1 MHz
37.5-38.0 GHz	Space research (Non-geostationary)	-120	-120 + 0.75 (θ-5)		-105		1 MHz
37.0-38.0 GHz	Space research [Geostationary)	-125	-125 + (θ-5)		-105		1 MHz
37.5-40.0 GHz	Fixed-satellite (Non-geostationary)	-130 [10,16]	**5°- 15°**	**15° - 25°**	**25° - 30°**	**30° - 90°**	1 MHz
			-130 [10,16]	-130 + (θ-15)/1.5 [10,16]	-123.333 + (θ-25)/1.5 [10,16]	-120 [10,16]	
37.5-40.0 GHz	Fixed-satellite (Geostationary)	-135 [16]	**5°- 15°**	**15° - 25°**	**25° - 30°**	**30° - 90°**	1 MHz
			-135 [16]	-135 + (θ-15) [16]	-125 + (θ-25) [16]	-120 [16]	
40.0-42.0 GHz	Fixed-Satellite (Non-geostationary) Mobile-Satellite	-115 [10]	-115 + 0.5 (θ-5) [10]		-105 [10]		1 MHz
40.0-42.0 GHz	Fixed-Satellite (Geostationary)	-120	**5° - 15°**	**15° - 25°**	-105		1 MHz
			-120 + (θ-5)	-110 + 0.5 (θ-15)			
42.0-42.5 GHz	Fixed-satellite (Non-geostationary)	-130 [16,17]	**5°- 15°**	**15° - 25°**	**25° - 30°**	**30° - 90°**	1 MHz
			-130 [16,17]	-130 + (θ-15)/1.5 [16,17]	-123.333 + (θ-25)/1.5 [16,17]	-120 [16,17]	
42.0-42.5 GHz	Fixed-satellite (Geostationary)	-135 [16,17]	**5°- 15°**	**15° - 25°**	**25° - 30°**	**30° - 90°**	1 MHz
			-135 [16,17]	-135 + (θ-15) [16,17]	-125 + (θ-25) [16,17]	-120 [16,17]	

USA/1.4/6
MOD

10 **S21.16.4** The values given in this box shall apply to emissions of space stations of non-geostationary satellites in networks oueratine with 99 or fewer satellites. Further study concerning the applicability of these values is necessary in order to apply them to networks oueratine with 100 or more satellites.~~until such time as modified by a competent world radiocommunication conference~~. For non-eeostationarv fixed-satellite service systems operating in the band 41.5-42.0 GHz, see also Resolution **128** (MOD WRC-2000).

USA/1.4/7
ADD

16 **S21.16.10** The power flux densitv of a fixed-satellite service space station oueratine in this band can exceed the values given in this box by up to 10 dB for no more than 1% of the time: provided that before oueratine in excess of the limits in this box, the agreement of all administrations affected by the increase shall have been obtained. For non-geostationarv fixed-satellite service systems oueratine in the band 41.5-42.0 GHz, see also Resolution **128** (MOD WRC-2000).

USA/1.4/8
ADD

17 **S21.16.11** The values in this box require further studv for fixed-satellite service urotection of the radio astronomy service. Fixed-satellite service systems shall not be imulemented in this band until studies are comuleted in accordance with Resolution **128** (MOD WRC-2000).

Reasons: The PFD-review objectives of Resolutions **133 (WRC-97)** and **129 (WRC-97)** have been met. The values stated above for FSS systems are consistent with the Report of the Conference Preparatory Meeting for WRC-2000 and those included in a draft new recommendation approved by the ITU-R. See Draft New Recommendation [4-9S/AH1], Maximum Allowable Values of Power Flux-Density at the Surface of the Earth Produced by Nan-Geostationary Satellites in the Fixed-Satellite Service Operating in the 37.5-40.5 GHz and 40.5-42.5 GHz Bands to Protect the Fixed Service. The studies under Resolution **129** were done with respect to the Fixed Service but are assumed to be adequate for protecting the co-primary terrestrial Broadcasting Service as well. In addition, studies have demonstrated the suitability for application to FSS systems of higher pfd limit in the 40.5-42.5 GHz band.

USA/1.4/9
SUP

~~Resolution 133 (WRC-97)~~

~~Sharing Between the Fixed Service and Other Services in the Band 37-40 GHz~~

Reason: Consequential

USA/1.4/10
SUP

~~Resolution 129 (WRC-97)~~

~~Criteria and Methodologies for Sharing Between the Fixed-Satellite Service and Other Services with Allocations in the Band 40.5-42.5 GHz~~

Reason: Consequential

Proposal for the addition of the Mobile-Satellite **Service** in the **40.5-41 GHz** band, and the addition of the Fixed-Satellite Service in the **40.5-42.5 GHz** band in Region **1**

Background Information: Resolution **134** (WRC-97) makes the date of the provisional application of the allocation to the FSS io Regions 1 and 3 in the band 40.5-42.5 GHz 1 January 2001, and calls for review of the allocation and provisional application date. On the basis of studies conducted in the ITU-R, it is appropriate to advance the date of the application of the FSS allocation in Regions 1 and 3 to 2 June 2000 (upon the conclusion of WRC-2000), and to extend the allocation to all of Region 1 (thereby enabling the removal of RR **S5.551C,** RR **S5.551D** and RR **S5.551E,** and the suppression of Resolution **134** (WRC-97)).

WRC-97 provided that fixed-satellite service systems in the band 41.5 - 42.5 GHz may not be implemented until technical and operational measures have been identified and agreed within ITU-R to protect the radio astronomy service in the band 42.5 - 43.5 GHz from harmful interference. Similarly, there is the potential for harmful interference to the radio astronomy service from broadcasting-satellite service systems operating in the band 41.5-42.5 GHz. The United States believes that the range ofpotential impact on radio astronomy service in the band 42.5-43.5 GHz from FSS (space-to-Earth) networks in the adjacent hand can prudently be limited to the band 42.0-42.5 GHz, and that the footnote in Article S5 and associated resolution (Resolution **128** (WRC-97)) should be adjusted accordingly. The United States also believes that this limitation should apply to the broadcasting-satellite service in the band 42.0-42.5 GHz.

On the basis of these conclusions, the following proposals are made:

Article S5

GHz

40.5-41

USA/1.4/ 11
MOD

Allocation to Services		
Region 1	Region 2	Region 3
40.5-41 FIXED **S5.FSS S5.MSS** FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING- SATELLITE Mobile MOBILE-SATELLITE space-to-Earth ~~S5.551D~~	**40.5-41** FIXED **S5.FSS S5.MSS** FIXED-SATELLITE (space-to-Earth) ~~S5.551E~~ BROADCASTING BROADCASTING- SATELLITE Mobile MOBILE-SATELLITE [space-to-Earth) S5.551C	**40.5-41** FIXED **S5.FSS S5.MSS** FIXED-SATELLITE (space-to-Earth) ~~S5.551E~~ BROADCASTING BROADCASTING- SATELLITE Mobile MOBILE-SATELLITE (space-to-Earth) S5.551C

41-42.5

USA/1.4/ 12 MOD

Allocation to Services		
Region 1	Region 2	Region 3
41-42.5 FIXED <u>S5.FSS</u> <u>FIXED-SATELLITE</u> <u>**S5.HDFS S5.551X**</u> (mace-to-Earth) BROADCASTING BROADCASTING-SATELLITE Mobile S5.551B ~~S5.551D~~	**41-42.5** FIXED <u>S5.FSS</u> FIXED-SATELLITE <u>**S5.HDFS S5.551X**</u> (space-to-Earth) S5.551B ~~S5.551E~~ BROADCASTING BROADCASTING-SATELLITE Mobile S5.551C	**41-42.5** FIXED <u>S5.FSS</u> FIXED-SATELLITE <u>**S5.HDFS S5.551X**</u> (space-to-Earth) S5.551B ~~S5.551E~~ BROADCASTING BROADCASTING-SATELLITE Mobile S5.551C S5.551F

Reasons: With the exception of sharing issues and studies identified in Resolution 128, studies in ITU-R confirm the feasibility of the fixed-satellite service allocation in the bands 40.5-42.5 GHz, and the need for harmonized global allocations. With the elevation of the allocation to full primary status in all 3 regions, the footnote allocation for countries in Region 1 can be removed. Those countries that are listed or that have territories listed in RR **S5.551C** should give consideration to whether the alternative allocation in certain countries and territories in Regions 2 and 3 can be suppressed. Acceleration of the effective date allows for removal of the reference to Resolution **134 (WRC-97).** In advancing this proposal, it is proposed that broadcasting-satellite service and fixed-satellite service systems in the band 42.0-42.5 GHz not be implemented until technical and operational measures have been identified and agreed within ITU-R to protect the radio astronomy service in the band 42.5-43.5 GHz from harmful interference.

USA/1.4/13 MOD

S5.551B The **use** of the band ~~41.5-~~ **42.0-42.5** GHz **by** the <u>broadcasting-satellite service and</u> fixed-satellite service (space to-Earth) **is** subject to Resolution **128** (MOD WRC-<u>2000</u> ~~97~~). <u>The limitation on the broadcastine-satellite service shall apply to systems where advanced publication materials are received **by** the Bureau after **2** June 2000.</u>

Reason: Adjustment of the fixed-satellite service amount ***of*** spectrum subject **to** protect the radio astronomy service (RAS), and to protect RAS from possible interference from the broadcasting-satellite service per modification of Resolution 128.

USA/1.4/14 SUP

~~S5.551D~~

Reason: With the elevation of the allocation to full primary status in all 3 regions, the footnote allocation for countries in Region 1 can be removed.

USA/1.4/ 15 SUP

~~S5.551E~~

Reason: With the elevation of the allocation to **full** primary status in all **3** regions, the footnote allocation for countries in Region 1 can be removed.

USA/1.4/ 16 ADD **<u>S5.551X</u>** Use of the band **42.0-42.5 GHz** by the fixed-satellite service shall be limited to gateways

Reason: To reduce the potential harmful interference caused to the radio astronomy service in the **42.5-43.5 GHz** band.

USA/1.4/ 17 SUP

Suppression of Resolution 134 (WRC-97)

~~Resolution 134 (WRC-97)~~
~~Use of the frequency band 40.5-42.5 GHz~~
~~by the fixed-satellite service~~

Reason: Consequential to change of allocation.

USA/1.4/ 18 MOD

RESOLUTION 128 (<u>MOD</u> WRC-~~97~~<u>2000</u>)

Allocation to the <u>broadcasting-satellite service and</u> fixed-satellite service (space-to-Earth) in the ~~41.5~~ <u>42.0</u>-42.5 GHz band, <u>use of the 41.5-42.0 GHz band by non-geostationary fixed-satellite service systems,</u> and protection of the radio astronomy service in the 42.5-43.5 GHz hand

The World Radiocommunication Conference (~~Geneva, 1997~~<u>Istanbul, 2000</u>),

considering

a) that ~~this Conference~~ <u>WRC-97</u> added a **primary** allocation to the fixed-satellite service (space-to-Earth) in the band ~~41.5~~ <u>42.0</u>-42.5 GHz in Regions **2** and 3 and in certain countries in Region 1<u>, and this Conference expanded this allocation to include all of Region 1,</u> and that this band is adjacent to the band **42.5-43.5 GHz** which is allocated, ***infer alia,*** to the radio astronomy service **for** both continuum and spectral line observations;

b) <u>that there is also a worldwide primary allocation to the broadcasting-satellite service in the **42.0-42.5** GHz band,</u>

c) that unwanted emissions from space stations in the <u>broadcasting-satellite service and</u> fixed-satellite service (space-to-Earth) in the band ~~41.5~~ <u>42.0</u>-42.5 GHz may result in harmful interference to the radio astronomy service in the band 42.5-43.5 GHz;

d) <u>that aggregate unwanted emissions from space stations in the non-geostationary fixed-satellite service (space-to-Earth) in the band **41.5 42.0** GHz may result in harmful interference to the radio astronomy service in the band **42.5-43.5** GHz;</u>

e) that various technical means may be used to reduce these unwanted emissions from space stations in the <u>broadcasting- and</u> fixed-satellite services;

f) that a limited number of radio astronomy stations worldwide require protection, and that there may be means to limit the susceptibility of radio astronomy receivers to interference,

taking into account

the relevant provisions of the Radio Regulations,

resolves

that administrations shall not implement broadcasting-satellite service systems where advanced publication materials are received hv the Bureau after **2** June **2000** and fixed-satellite systems in the hand ~~41.5~~ 42.0-**42.5 GHz** until technical and operational measures have been identified and agreed within ITU-R to protect the radio astronomy service from harmful interference in the band **42.5-43.5 GHz,**

invites *ITU-R*

1 to study, as a matter of urgency, the harmful interference that space stations in the broadcasting-satellite service where advanced uuhlication materials are received bv the Bureau after **2** June **2000** and fixed-satellite service (space-to-Earth) operating in the band ~~41.5~~ **42.0-42.5 GHz** may cause to stations in the radio astronomy service operating in the hand **42.5-43.5 GHz;**

2 to identify technical and operational measures that may be taken to protect stations in the radio astronomy service operating in the band **42.5-43.5 GHz,** including geographical separation and out-of-band emission limits to be applied to space stations operating in the broadcasting- satellite service where advanced uuhlication materials are received by the Bureau after **2** June **2000** and fixed-satellite service in the band ~~41.5~~ **42.0-42.5 GHz,** as well as measures that may be implemented to reduce the susceptibility **of** stations in the radio astronomy service to harmful interference;

3 to report on the results of ~~these~~ the studies in ***invites*** *ITU-R 1* ***and 2*** to the Conference Preparatory Meeting for WRC-~~99~~02/03,

~~4~~ to comulete the ongoing ITU-R studies on aggregate unwanted emissions from non-geostationary fixed-satellite service systems operating in the band 41.5-42.0 GHz for protection of the radio astronomy service ouerating in the band 42.5-43.5 GHz.

urges administrations

1 to participate actively in the aforementioned studies by submitting contributions to ITU-R,

2 when implementing non-geostationary fixed-satellite service systems, to take into account the results of studies identified in ***invites ITU-R 4.***

requests

WRC-~~99~~02/03 to take appropriate action based on those studies

Reasons: Consequential to the adjustment of the **FSS** spectrum necessary to protect the radio astronomy service, to protect it from possible interference from broadcasting-satellite service systems and the requested **ITU-R** studies have not been done.

USA/1.4/ 19
ADD

RESOLUTION XXX (WRC-2000)

Criteria and methodologies for sharing between the fixed-satellite service and the mobile and broadcasting services with co-primary allocations in the band 40.0-42.0 GHz

The World Radiocommunication Conference (Istanbul, 2000), *considering*

a) that there is a primary allocation to the fixed-satellite service (space-to-Earth) in the band 40.0-42.0 GHz;

b) that there are primary allocations to the fixed service in the band **40.0-42.0** GHz, to the mobile service in the band **40.0-40.5** GHz, and to the broadcasting service in the band **40.5-42.0** GHz;

c) that this Conference has determined that in the band **40.0-42.0** GHz, stations in the fixed service shall neither cause harmful interference to stations in the fixed-satellite service nor claim protection from harmful interference from fixed-satellite service stations operating in this band;

d) that, in conditioning fixed service **use** of the band 40.0-42.0 **GHz** through **No. S5.FSS**, WRC-2000 sought to encourage fixed-satellite service **use** of this band for high-density applications in the fixed-satellite service;

e) that although sharing is feasible between earth stations in the **FSS** and co-primary stations in the mobile and broadcasting services provided appropriate coordination procedures and/or operational techniques are employed, sharing may in practice become difficult when high geographic densities of such stations are deployed in bands heavily used by either service;

f) that it may be useful to consider the identification of the 40.0-42.0 GHz band **for** high-density applications in the fixed-satellite service;

g) that the deployment of high-density systems in the mobile service in the band 40.0-40.5 GHz and in the broadcasting service in the band 40.5-42.0 **GHz** may result in interference to stations in the fixed-satellite service;

h) that given ***considerings*** *a)* to *g)*, it would be useful to conduct sharing studies between fixed-satellite service earth station receivers and transmitters of the mobile and broadcasting services with co-primary allocations in the band 40.0-42.0 GHz;

i) that there is a need to establish sharing criteria to facilitate the co-existence of fixed-satellite service earth station receivers and transmitters of the mobile and broadcasting services with co-primary allocations in the band 40.0-42.0 GHz;

resolves to invite ITU-R

1 taking into account the above ***considerings,*** to undertake, as a matter of urgency, studies of appropriate criteria and methodologies for sharing between fixed-satellite service earth station receivers and transmitters of the mobile and broadcasting services with co-primary allocations in the band 40.0-42.0 GHz;

2 to report on the results of these studies to the Conference Preparatory Meeting for WRC-2002/03,

urges administrations

to participate actively in the aforementioned studies by submitting contributions to ITU-R,

requests

WRC-2002103 to take appropriate action based on the results of those studies

Reason: **To determine the appropriate sharing criteria between the fixed-satellite service and the broadcasting and mobile services with co-primary allocations in this hand in accordance with <u>S5.FSS</u>.**

ATTACHMENT 3

ANNEX 2

(to PDNR[4-9S/PFD-40GHz])

The extent to which GSO FSS satellites providing services to gateway earth stations in the bands 37.5-40 GHz and 40.5-42.5 GHz would need to operate at power flux-density levels in excess of a given clear-sky power flux-density levels to overcome fading conditions

1 Introduction

This Annex presents data on the extent to which FSS satellites would need to overcome fading conditions in their use of FSS gateway earth stations in the 37.5-40 GHz and 40.5-42.5 GHz bands. Both the percentage of time and the level of power control are discussed. Propagation conditions on the wanted and interfering paths are addressed in Annex 4.

2 Characteristics of GSO FSS systems

The characteristics of the GSO FSS system used in this Annex are based on the system parameters of GSO V1 FSS system as given in Annex 3 of Recommendation ITU-R S.[Doc. 4/40], intended to operate in the 37.5-40 GHz and 42-42.5 GHz hands.

The following is a summary of the system parameters of the GSO V1 FSS:

- Earth terminal antenna gain: 58.57 dBi.
- Polarization: circular.
- Receive noise temperature: 800 K.
- Interference degradation/allocation: 1.5 dB.
- Other losses (pointing loss, atmospheric loss, scintillation loss): 2.0 dB.
- Edge of coverage (EOC): 2.0 dB contour.
- System margin: 1.0 dB.
  - a) In normal clear-sky operation (pfd = Table S21-4 minus 12 dB).
    - i) Modulation: 8PSK.
    - ii) Required Eb/No: 12.37 dB.
    - iii) Maximum downlink power flux-density: Values in Table S21-4 minus 12 dB.
  - b) In fading conditions:
    - i) Modulation: QPSK.
    - ii) Required Eb/No = 7.88 dB.
    - iii) Desired link availability: 99.9%.

iv) Minimum downlink available fade margin: 12 dB.

- **Number of carriers:** $N = 10$.
- **Pfd = − Table S21-4 minus** 10 dB.

v) **Maximum** downlink available fade **margin:** 22.1 dB.

- Number of carriers: N = 1.
- Pfd= - Table S21-4 **minus** 0 dB.

As already stated above, the GSO V1 system operating in the 37.5-40 GHz and 4242.5 GHz bands plan to use these bands for gateway (direction: satellite-to-gateway) applications, with a desired link availability of 99.9%. In order to achieve the desired link availability and system capacity, the transmit data rate, modulation and coding are adjusted in the GSO V1 system. For example, in the normal clear-sky operation, the system operates with higher order modulations (8PSK), light coding and high transmit **data** rate to achieve the desired capacity. During fading conditions, the system will operate with conventional ***QPSK*** modulation, heavy coding and reduced transmit data rate to achieve the desired link availability. In these frequency bands, the GSO V1 system plans to operate at the power flux-density limits in Table S21-4 minus 12 dB in normal operation and to operate up to the power fluxdensity limits as shown in Table S21-4 during fading conditions.

In addition, all proposed GSO FSS systems plan to **use** high gain, narrow spot-beam antennas for the transmit and receive beams. Based on Recommendations **ITU-R** F.1328 and ITU-R S.[Doc. 4/40], the satellite antenna gain of GSO FSS systems operating in this band is in a range of 53.0-55 dBi. Figure, 1 shows the antenna contours and the elevation angles.

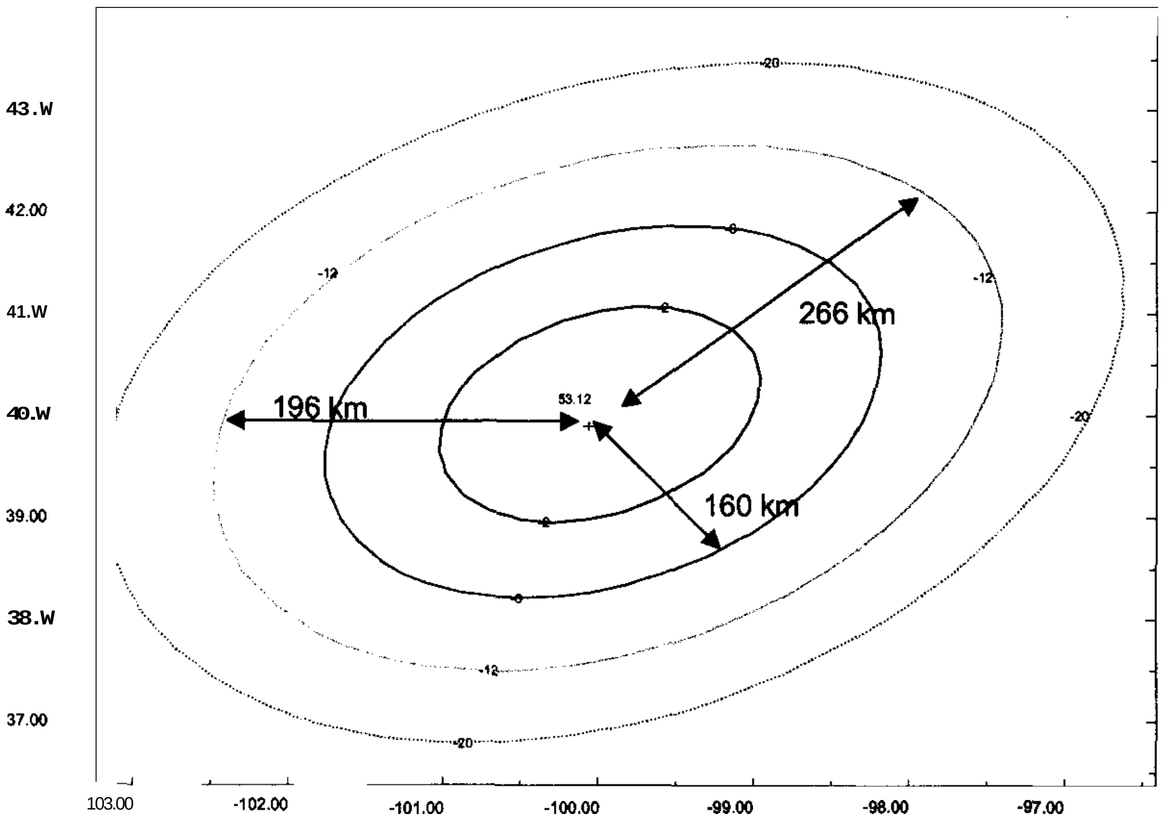


FIGURE 1

Satellite transmit antenna contour (satellite location: 115 west)

3 The percentage of time during which fixed-satellite service nominal clear-sky power flux-density levels may be exceeded to overcome fading conditions

3.1 Downlink power flux-density and link availability

The downlink power flux-density can be shown as:

$$pfd = \text{EIRP} - L_s + 10Log\left(\frac{1MHz}{BW}\right) + G(1m2)$$

The required downlink E_b/N_o can be computed as:

$$\frac{E_b}{N} = EIRP - L_s - L_{ot}, - L_p - \&in \quad - EOC - M - D_{\text{int}} + G_{FSS} - 10Log(bps) - (-228.6 + 10 * \log(T))$$

Then

$$pfd = \left(\frac{E_b}{N_0}\right) - 10Log\left(\frac{sps}{bps}\right) - G_{FSS} + 20Log(f) + 21.45 + 10Log(T) + EOC + M_s + L_{atm} + L_p + L_{scin} + D_{\text{int}} - 228.6 + 60$$

or

$$pfd = \left(\frac{E_b}{N_0}\right) - 10Log\left(\frac{sps}{bps}\right) - G_{FSS}(0) + 20Log(f) + 10Log(T) - 147.15 + EOC + M_S + L_{other} + D_{\text{int}}$$

where:

- E_b/N_o : required downlink E_b/N_o (dB)
- BW : necessary bandwidth = sps (symbol rate)
- sps/bps : symbol rate/bit rate. For *QPSK*, sps/bps = *0.5;* for **8PSK,** spshps = **1/3**
- $G_{FSS}(0)$: FSS earth terminal antenna peak gain (dBi)
- T : earth station receiver noise temperature **(k)**
- **f** : frequency (GHz)
- **EOC** : edge of coverage (dB)
- M_s : system margin (dB)
- L_{other} : L_p(pointing **loss)** + L_{atm}**(atmospheric loss)** + L_{scin}(scintillation loss)
- D_{int} : Degradation due to interference.

3.1.1 In normal operation (8PSK modulation)

Minimum downlink power flux-density

Based on the GSO V1 FSS system parameters shown in Section 2, in order to close the link, the minimum required downlink power flux-density level in clear-sky operation is −121.2 **dB(W/(m^2·MHz)).**

The calculated downlink power flux-density, −121.2 dB(W/(m^2·MHz)), is based on an earth terminal antenna diameter of 2.7 m. It has however to be stressed that most proposed FSS systems in the **40/50 GHz** hands do not use Earth terminal antennas bigger than **2.4** m for their gateways because the complexity of auto track antennas capable of minimizing pointing loss in these frequency bands is very **high.** ***Considering*** e) of Recommendation ITU-R S.[Doc. **4/40]** states that "the feasibility of using larger antennas having a diameter greater than 2.4 m (D/λ >> 300), given the effects of main reflector distortion, surface roughness, radome attenuation and auto tracking antenna capable of minimizing loss in the 37.5-42.5 GHz band, remains to he determined." In this frequency band, if the Earth terminal size increases, the actual antenna gain may not be increased due to the pointing **loss** and the root-mean-square (rms) surface tolerance. The pointing **loss** and the gain reduction due to antenna surface tolerance can be shown **as** follows:

$$\text{Pointing Loss} = -3\left(\frac{2\Delta\theta}{\theta_3}\right)^2 \text{dB}$$

$$\text{Reduction due to antenna surface tolerance} = 10Log\left(\exp\left[-\left(\frac{-4\pi e}{\lambda}\right)^2\right]\right) dB$$

where:

$\Delta\theta$: pointing error

e: antenna rms surface tolerance.

The power flux-density limits of ***GSO*** FSS operating in the band, as shown in Table S21-4 and Recommendation ITU-R SF.[Doc. 4-9/BL/3] are –127/–107/–105 dB(W/(m^2·MHz)). In clear-sky conditions. the power flux-density of ***GSO*** V1 **FSS** system is assumed not to exceed –139/–119/–117 dB(W/(m^2·MHz)) which represent Table S21-4 minus 12 dB. In order to meet the clear-sky power flux-density levels of –139/–119/–117 dB (W/(m^2·MHz)) and the required minimum downlink power flux-density for normal operation of –121.2 dB(W/(m^2.MHz)), the minimum operational elevation angle of FSS satellites is 17.7 degrees. Operation at higher elevation angles is preferred.

Based on characteristics of GSO V1 systems, and in particular 2.7 m antennas the downlink power flux-density levels, –139/–119/–117 dB(W/(m^2·MHz)) may be adequate for GSO **FSS** gateway stations operating in clear-sky conditions. However, the use of higher modulations, such as 16QAM, and/or lower antenna diameter at these power flux-density levels, may not be feasible.

Link availability *(GSO* V1, clear-sky pfd)

Figures 2 and 3 show the available clear-sky margin, the minimum operational elevation angle and the link availability, respectively. Calculated link availability is based on the available fade margin **as** shown in Figure **2** and an earth station located at 40°N latitude and 95°W longitude. Based on Recommendation ITU-R **P.618-6**, the link availability of an earth station with an elevation angle of 17.7 degrees and a 0.1 dB fade margin is –50%. **Also,** based on this recommendation, the model only estimates the attenuation to be exceeded for percentages of an average year, in the range 0.001% to 5%. In this study, if the calculated link availability is less than 95%, since there is an absence of an appropriate model 95% was assumed.

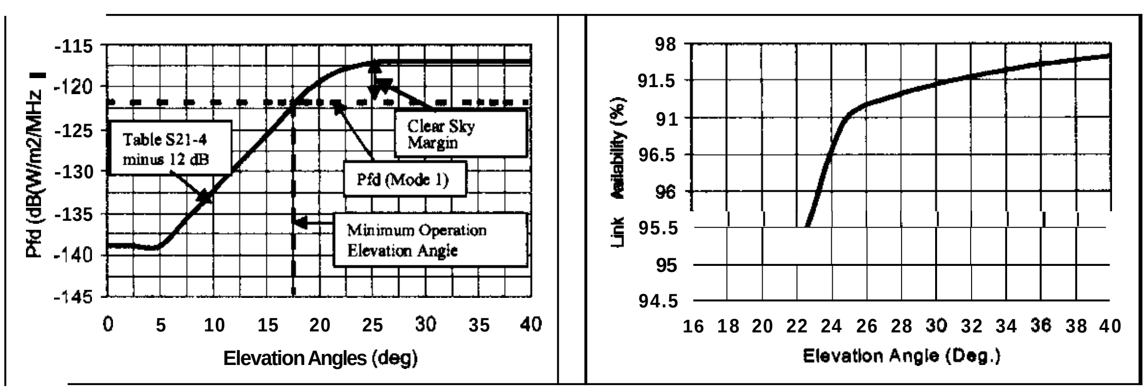


FIGURE 2

Available clear-sky fade margin at Table S21-4 minus 12 dB levels vs. elevation angle, for *GSO* V1

FIGURE! 3

Link availability based on clear-sky fade margin vs. elevation angle for *GSO* V1

Figure 4 shows the worldwide link availability. The following parameters are used in the calculation:

- Elevation angle = minimum (maximum elevation angle (latitude), ***25*** deg.).
  a) Elevation angle depends on a satellite location and an earth station location.
  b) In this study, the minimum operational elevation angle of GSO **FSS** system is 25 degrees.
- Fade margin = (Table S21-4 minus 12 dB) – (required downlink power **flux-**density).

Figure 4 shows that if the FSS systems, of the type GSO V1, operate at the **power** flux-density values in Table S21-4 minus 12 dB, in clear-sky conditions, they may only achieve 99% link availability which is not sufficient for gateway applications, for most locations around the world. This calculation is based on the use of a 2.7 m-diameter earth terminal. Other FSS system implementations will yield less favourable results

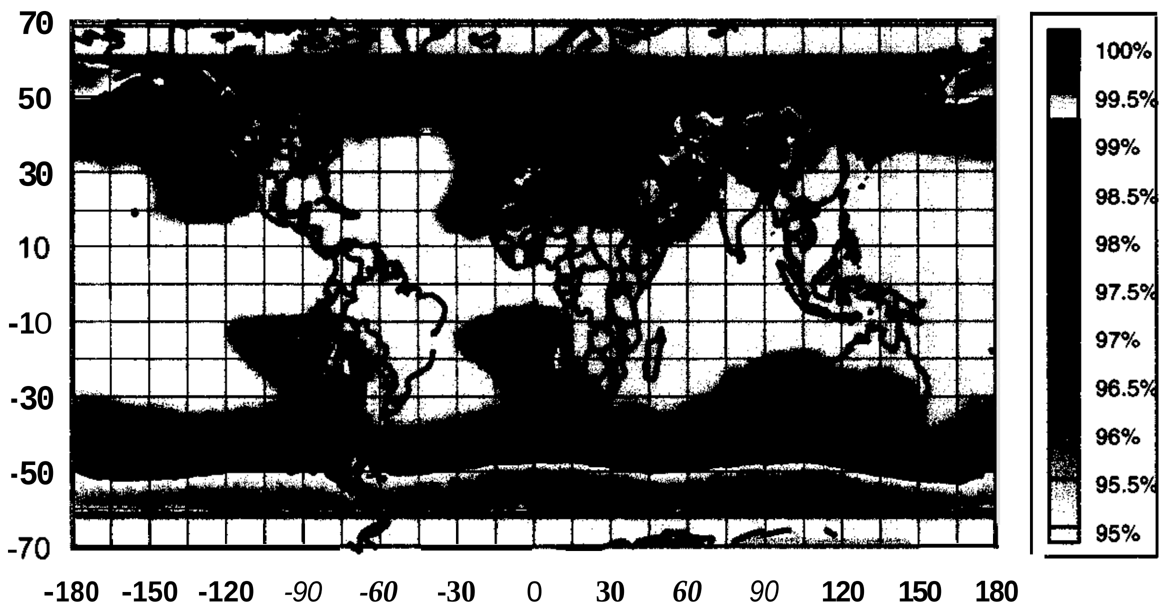


FIGURE 4

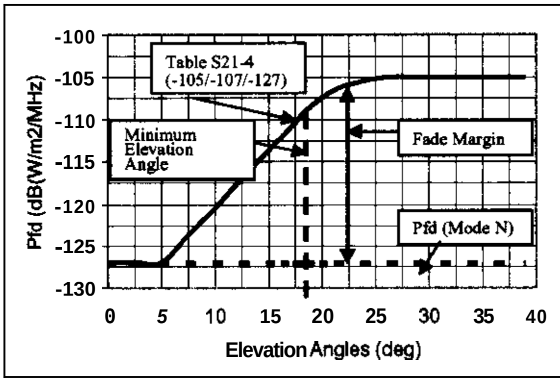
Link availability (pfd = Table S21-4 minus 12 dB, 8PSK) with *GSO* V1 type FSS

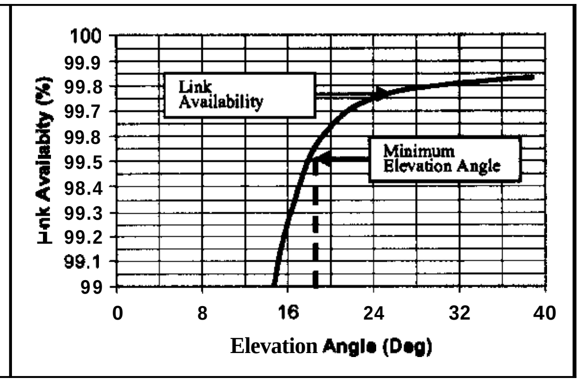
3.1.2 In fading conditions

Rain attenuation is severe in the **40** GHz band. In order to achieve the desired link availability and system capacity, **FSS** systems operating in this band must use downlink fade compensation techniques. The GSO V1 system, **as** shown in Recommendation ITU-R S.[Doc. **4/40]**, plans to use adjustable data rates, modulation and coding **as** mitigation techniques. Depending on the extent of the rain attenuation, the GSO V1 system may change the modulation, coding and transmit data rate to achieve the required rain fade margin. For example, if the fading is less than ***5*** dB, GSO V1 may just change the coding, from light coding to heavy coding. However, if the fading is 22 dB, the GSO V1 may change both modulation from **8PSK** to **QPSK** and coding from light to heavy.

In order to achieve the desired link availability, **FSS** systems must reduce their systems' capacity by operating with a lower order modulation, changing the coding **from** light coding to heavy coding, and reducing the number of carriers, etc. The actual downlink power fluxdensity level at the **FSS** receiver in fading conditions is –127.5 **dB(W/(m^2·MHz))**. Therefore, the maximum downlink fade margin is 22.5 dB **(–105** – (–127.5)); however, it will depend on the elevation angles.

Figures 5 and ***6*** show the maximum available downlink fade margin and the link availability, respectively, for ***GSO*** V1.





(Location: 40 N latitude, ***95*** W longitude)

FIGURE **5**

The maximum downlink fade margin at the Table S21-4 pfd limits vs. elevation angle

FIGURE ***6***

The link availability based on maximum downlink fade margin vs. elevation angle

Figure 7 shows the worldwide link availability of the GSO **V1** FSS system

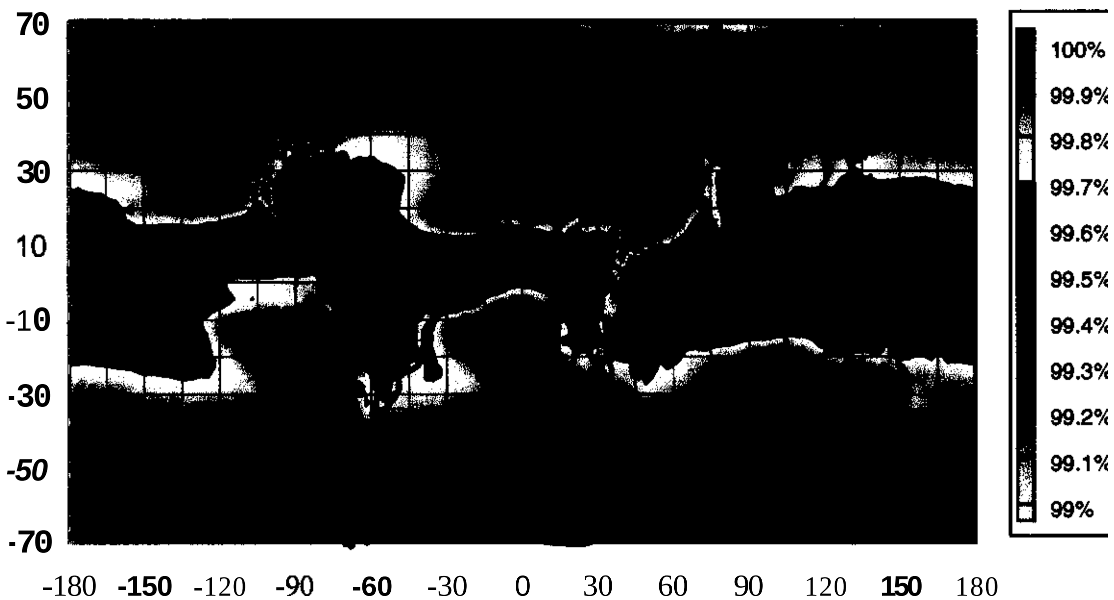


FIGURE 7

Link availability (pfd = –127/–107/–105 dB(W/m^2·MHz); QPSK, rain fade margin: 22.5 dB)

Figure 7 shows that even with *22.5* dB fade margin, the GSO **V1** FSS systems operating in the **37.540 GHz** band will not achieve the desired link availability (99.9%) in [most] parts of world.

[In addition, Figure *6* above shows that, even in low rain rate zones, the required availability of 99.9% is not achieved for a wide range of elevation, even up to 40/50° elevation, which makes *GSO* V1 system only operable in low latitude were such high elevation can be obtained, i.e lower than 35/40' latitude.
In conclusion, it **is** clearly shown that *GSO* V1 availability is limited by both minimum elevation which implies a maximum operation latitude (35/40°) and rain rate zone which, as described on Figure 7, implies in most of the longitudes, a minimum operation latitude (up to 35 °).]
The results are that such **FSS** systems in the 37.5-42.5 GHz band will only be able to operate at their required availability in limited part of the world.

3.2 Example calculation of the percentage of time during which FSS satellites would need to implement fade compensation techniques, without regard to the potential impact on HDFS receivers

The following is an example calculation of the percentage of time an hypothetical FSS systems providing service to one single gateway would need to implement fade compensation techniques to overcome fading conditions. Fade compensation techniques considered in this Annex include modulation changes, coding changes and increased downlink power density. Other methodologies can also he utilized to estimate this percentage of time. Further study is required to accurately quantify this parameter, and to estimate the percentages of time for incremental power increases (0 to 12 dB) as required.
The percentage of time is based on the average for the year during which the GSO V1 FSS systems would need to implement fade compensation techniques, by a required amount, to overcome fading conditions. In the following calculations, no fade compensation techniques (use of heavy coding, lower **order** modulation, etc.) are assumed which can provide additional margin to increase the availability. The percentage is calculated as follows, for a given fade margin and a given rain rate zone :
% time = Link availability (X fade margin) - Link availability (clear-sky fade margin).

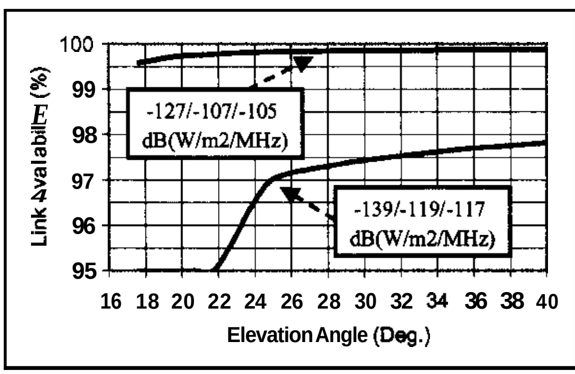


FIGURE 8

% time during which GSO V1 FSS would need to exceed the clear-sky pfd levels to overcome fading conditions (at x dB fade margin)

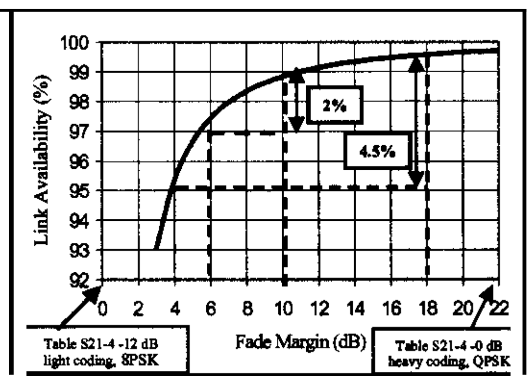


FIGURE 9

Yo time (example for y° elevation)

Figure **8** shows for a fade margin of x dB and rain rate zone (TBD) the link availability when the FSS systems operate at clear-sky conditions **of** modulation, coding and power fluxdensity and when the satellite operates under conditions to yield the maximum fade margin, i.e., changed modulation, heavy coding and the S21-4 power flux-density **limits** (–127/–107/–105 dB(W/(m^2·MHz)). The percentage of time during which FSS satellites would need to implement fade compensation to achieve the desired link availability *can* he computed as the difference between two link availabilities. For example, the percentages of time during which the FSS must **use** fade compensation techniques to overcome the required rain fade margin on one path between the satellite and a gateway of from 6 dB to 10 dB and from 4 dB to 18 dB are 2% and 4.5%, respectively, as shown in Figure 9. Figure *8* also shows that for lower elevation (e.g. 22° as **on** Figure *8)* this percentage of time cannot be calculated using Recommendation ITU-R P.618 since the availability is less than 95%.

As an example, Figures 8 and 9 indicate that the percentage of time during which GSO V1 FSS satellites would need to employ fade compensation techniques can be up to 5% of the time for one single gateway earth station. It depends, among other things, on the required operational power flux-density level of the FSS satellites during the fading conditions, the rain zone and the elevation angle of the slant path.

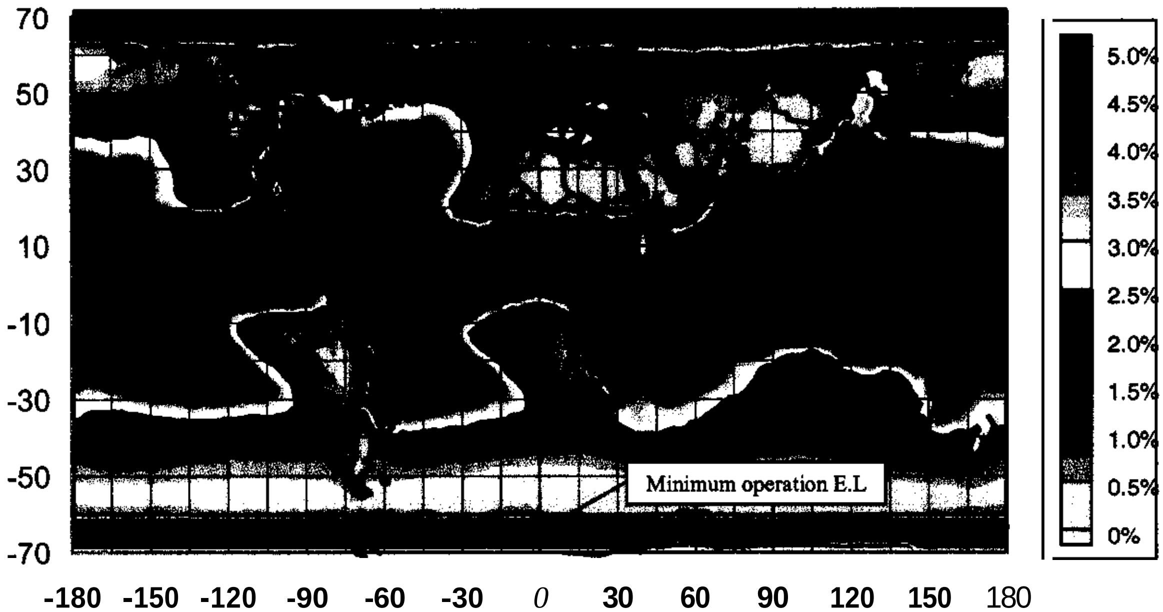


FIGURE 10

Percentage of time during which FSS systems would need to use some type of fade compensation technique, including modulation and coding and/or satellite power density increase

The percentage of time based on the average year during which GSO V1 FSS satellites would need to implement fade compensation by some amount for different locations around the world is shown in Figure 10 for an elevation of y°

As mentioned, fade compensation can take several forms, changing modulation, adding coding or increasing the downlink power density. The following are two examples of the calculated percentage of time during which the FSS systems could increase the clear-sky power flux-density levels to overcome fading conditions[1].

Location # 1
Latitude (North) 45
Longitude (East) 95
Rain zone K (42 mm/h)
Elevation angle (degrees) 25

Power flux-density	Fade margin	Mode	Link availability*	%Time
–117 dB(W/(m^{2}·MHz))	4.5 dB	8PSK/Light Code	96.60%	–
–117 dB(W/(m^{2}·MHz))	7.5 dB	QPSK/Light Coding	98.65%	2.05%
–117 dB(W/(m^{2}·MHz))	10.5 dB	QPSK/Heavy Coding	99.27%	0.62%
–114 dB(W/(m^{2}·MHz))	13.5 dB	QPSK/Heavy Coding	99.55%	0.27%
–111 dB(W/(m^{2}·MHz))	16.5 dB	QPSK/Heavy Coding	99.69%	0.15%
–108 dB(W/(m^{2}·MHz))	19.5 dB	QPSK/Heavy Coding	99.78%	0.09%
–105 dB(W/(m^{2}·MHz))	22.5 dB	QPSK/Heavy Coding	99.84%	0.06%

* Including 1 dB degradation due to noise temperature increase.

Power flux-density	Fade margin	Mode	Link availability*	%Time
–117 dB(W/(m^{2}·MHz))	4.5 dB	8PSK/Light Code	98.91%	–
–117 dB(W/(m^{2}·MHz))	7.5 dB	QPSK/Light Coding	99.60%	0.69%
–117 dB(W/(m^{2}·MHz))	10.5 dB	QPSK/Heavy Coding	99.80%	0.20%
–114 dB(W/(m^{2}·MHz))	13.5 dB	QPSK/Heavy Coding	99.88%	0.08%
–111 dB(W/(m^{2}·MHz))	16.5 dB	QPSK/Heavy Coding	99.92%	0.04%
–108 dB(W/(m^{2}·MHz))	19.5 dB	QPSK/Heavy Coding	99.95%	0.02%
–105 dB(W/(m^{2}·MHz))	22.5 dB	QPSK/Heavy Coding	99.96%	0.02%

* Including 1 dB degradation due to noise temperature increase.

As shown in the tables, the actual requirement to increase power density will probably occur for a small portion of the time for a single gateway earth station system. It is worth

1 The calculated rain loss used in these tables is based upon Recommendation ITU-R P.618-7.

noting that the required availability of 99.9% is only achieved **for** the system deployed in the lower rain zone E and for high elevation angles.

3.3 Conclusions

Based on the studies, and the assumptions made therein, it can he assumed that the percentage of time during which the ***GSO*** V1 FSS system would need to use some type of fade compensation technique, including modulation and coding and/or satellite power density increase, would be on the order of **1-5%** for one single gateway earth station. Further studies are required to refine and improve this estimate **as** to take into account other types of ***GSO*** FSS systems.

However, it should be stressed that under these conditions the ***GSO*** V1 FSS system, that actually represent an optimistic design, would not be able to achieve its required availability in most part of the world, mainly due to rain attenuation which impacts on minimum and maximum latitude of operation.

This Annex does not consider the effect of earth station diversity upon the percentage of time a ***GSO*** FSS would be required to employ other fade compensation techniques in high rain regions. Further studies **are** required to verify the feasibility of diversity and make an accurate estimation of the effect of this factor.

Finally, fade compensation techniques may be feasible and present some benefits with regard to sharing between FS and FSS. Administrations, satellite designers and manufacturers should also consider its limitations described in this Annex.